FIELD CRITERIA FOR SAMPLING EFFLUENTS AND RECEIVING WATERS

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PREFACE

This manual entitled "Field Criteria for Sampling Effluents and Receiving Waters" deals with key elements of field sampling such as siting, collection procedures and flow measurement. The reliability and accuracy of monitoring results are as critically dependent on field sampling as they are on the analytical follow-up and this manual presents criteria designed to ensure that representative samples of effluents and receiving waters (including ground waters) are provided for subsequent laboratory analysis.

It is intended that this manual on field sampling would be used in conjunction with the Ministry manual on laboratory analysis entitled "A Laboratory Manual for the Chemical Analysis of Waters, Wastewaters, Sediments and Biological Materials (1976 edition including updates)". The monitoring procedures contained in these manuals define current Ministry of Environment monitoring standards and may be cited in Waste Management permits, approvals and orders, as well as legislated requirements.

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I. Effluent Sampling

(a) Sample Location

Effluent sampling is to be undertaken at an appropriate location within the effluent stream to ensure that the collected samples are representative. Representative sampling locations occur where the effluent is homogeneous and will most likely be found in a zone of turbulent mixing (immediately downstream from a flow disturbance such as a pipe constriction, bend, or flow control device). When two separate effluent streams combine the sampling location should be at least 6 pipe diameters downstream from the point of confluence.

Samples should normally be extracted near the centre of the effluent stream in order to avoid boundary effects and biasing due to material which has a strong tendency to sink or float (unless these materials are the subject of the sampling program).

The sampling location is ultimately determined by the Ministry of Environment in consultation with the Permittee such that the site is mutually agreeable for the purpose of determining compliance with permit conditions (effluent discharge quality). When data is to be stored on the Ministry of Environment's data storage and retrieval system (SEAM), a SEAM site number will be established by Ministry staff and this number should be used by the Permittee. The sampling facility itself must conform to Workers' Compensation Board and other applicable safety requirements and be readily accessible under all expected weather conditions.

(b) Sample Collection Procedures

Waste Management Permits normally specify the type of sampling to be conducted (grab, composite, or continuous). The Permit may also define certain process events which require specific sampling activities.

(i) Grab Sampling

Grab samples are generally specified when the concentration of a parameter under consideration is not expected to vary significantly with time; or when values associated with extreme events are desired.

Grab samples may be obtained manually or by using an automatic sampler. Individual grab samples must have a minimum volume of 1 litre and be collected over a period not exceeding 15 minutes.

Note that manual grab samples are generally required when hydrophobic parameters (e.g., oil and grease) are sampled.

(ii) Composite Sampling

Composite samples are generally specified when the concentration of the parameter under consideration is expected to vary with time (or location).

Composite samples may be obtained manually or by using an automatic sampler. A composite sample is a combination of individual samples taken at equal intervals over the compositing period. The individual samples may be of equal volume or be proportional to the flow at the time of sampling. The compositing period is defined according to the terms of the Permit (i.e., daily, over a four-hour period, etc.). The sampling frequency may also be specified in the Permit, however, if not specified, the frequency shall be a minimum four times per hour over the compositing period.

The sample size should be adjusted such that the total composited sample volume is manageable (less than 10 litres), but sufficient to carry out the required analyses.

Flow proportional composite sampling is preferred when effluent flow rates vary significantly (variations exceeding ±15% of the daily mean greater than 10% of the time) and, if required, will normally be specified as a condition of the Permit.

(iii) Continuous Sampling

Continuous sampling refers to either the real-time measurement of a selected parameter (the list of parameters that can be measured in this manner is limited - pH, temperature, dissolved oxygen, conductivity, etc.) or the continuous collection of samples to form a composite sample.

(c) Sampling Frequency

The frequency at which samples are collected is specified in the Waste Management Permit and is based upon the monitoring objective and the variability of the process being measured.

(d) Specifications for Sampler Design and Operation

In order to avoid compromising the integrity of the sample, the collection, storage, and transport devices must be made of materials that are compatible with the effluent being sampled. Stainless steel, glass, plastic and teflon are generally acceptable for collection and short-term storage purposes depending upon the specific application. For example, plastic is not recommended for organics and stainless steel is not recommended for metals.

All containers used to transport samples to the laboratory are required to undergo the prescribed pre-treatment and cleaning procedures detailed in the Appendix.

Where possible, the sample collection container should also be used to transport the sample to the laboratory (e.g., as in the case of manual grab samples). If a sample collection container is used (and reused) to obtain samples but is not the container used to transport the sample to the laboratory, the procedure for cleaning and reuse must conform to the procedures appearing in item (h) below.

Automatic sampling devices (to collect grab or composite samples) are acceptable providing that the sample is in contact with only components made of acceptable materials (stainless steel, glass, plastic or teflon). Automatic sampling devices must be equipped with a purge mechanism to enable the sample line to be evacuated prior to sample extraction. The velocity in the sampling line should be a minimum of 0.75 m/s to prevent the settling of solid material.

In the case of composite sampling, it may be necessary to provide an interim storage vessel used to store component samples over a prescribed compositing period. This vessel must be made of acceptable materials, and the procedures for cleaning and reuse must conform to the procedures in item (h) below.

(e) Sample Preservation and Storage

Specifications for the chemical preservation of collected samples appear in the Appendix. All collected samples which require refrigeration (see Appendix) are to be immediately cooled and maintained at 4°C ± 2°C until analyzed. The elapsed time between sample collection and analysis should not exceed 48 hours for biochemical oxygen demand (BOD), nutrients, alkalinity, pH, phenols and coliform testing. In the case of composite samples, the elapsed time period shall commence when the last individual sample (making up the composite sample) has been collected.

(f) Additional Procedures for Dissolved Nutrients and Metals

If analyses for dissolved nutrients or dissolved metals (including mercury) is required, filtration of the sample using a 0.45 μ membrane filter should be carried out immediately after sample collection (and prior to the addition of acid preservatives for the metals sample). The Regional Waste Manager may waive the requirement for filtration of nutrient samples.

It should be demonstrated that the filters used are free from contamination which could interfere with subsequent analyses. In addition, blanks using distilled water and fresh filters should be provided with each batch of samples sent to the laboratory. The filtration apparatus must be made of acceptable materials and the procedures for cleaning and reuse must conform to the procedures specified in item (h) below.

(g) **Sample Splitting**

It may be necessary to reduce the size of the original sample (by transferring into separate containers) for multi-parameter analyses or quality control purposes. In such cases, the entire sample should be directed through an acceptable sample splitting device such as a "butter churn" sample splitter.

The sample splitter must be made of acceptable materials and the procedures for cleaning and reuse must conform to the procedures specified in item (h) below.

(h) **Re-use of Sampling Devices**

The cleaning and reuse of various sampling devices such as sample collection containers, sample splitters and filtration apparatus must conform to the following guidelines:

- Initial laboratory cleaning procedures, where indicated, are to follow the procedures specified in the Appendix.

- Prior to reuse in the field, scour if necessary, and then rinse three times with (distilled) water or sample, as appropriate. Rinsing with sample is recommended only if the sample does not contain high suspended solids. If organic parameters are to be sampled, rinse three times with acetone followed by a single rinse with distilled water.

- Restrict the use of individual sampling devices to samples which have similar characteristics and preferably to samples from the same site (i.e., devices used for effluent sampling must not under any circumstances be used for receiving waters).

II. Flow Measurement Procedures

Measurement of volumetric flow rates for effluent discharges is generally carried out on a continuous basis and a measurement is always required at the time a sample is collected. However, the location of the flow measurement may be different from the sampling location. The location is ultimately determined by the Ministry of Environment in consultation with the Permittee such that the site is mutually agreeable for the purpose of determining compliance with the permit conditions (effluent quantity).

The flow measuring system usually consists of a sensor, sending device and recorder. The overall accuracy of the system must be ±5% and all calibrations must be traceable to a primary standard. It is assumed that all manufacturer-supplied graphs, tables and charts are traceable to primary standards.

The type of flow measurement system depends upon the effluent characteristics (solids content, temperature, velocity, etc.) and the point of measurement (completely filled pipe or open channel). It is essential that the flow measuring device be installed according to manufacturer's requirements.

(a) Completely Filled Pipe Flow

There are several types of commercially available flow measuring devices (magnetic meter, venturi meter and orifice meter are the most common).

The magnetic flow meter works on the principle of induced voltage. It is useful in situations of high solids content and has very little associated head loss. The accuracy generally increases with velocity and the meter is relatively insensitive to turbulence.

The venturi meter requires an upstream stilling zone depending upon the ratio of the meter throat diameter to the pipe diameter (usually 5-10 pipe diameters). The meter operates by measuring fluid pressure.

The orifice meter can operate over a wide range of flows, but the head loss is significant and settled solids can accumulate upstream. Like the venturi meter, it operates by measuring fluid pressures.

(b) Open Channel Flow

The two main types of open channel flow measurement devices are the weir and Parshall flume.

A weir is a specifically designed dam (usually a plate) that is positioned in the effluent flow channel. The flow rate is a function of variations in the head upstream from the weir. The following requirements pertain to weir installations:

- The weir should be horizontal.

- The weir should be knife-edged if the plate thickness is greater than 3.2 mm.

- The head measurement device should be located upstream a distance of at least 2.5 times the head over the weir and be free from hydraulic disturbances.

- In order to reduce the velocity of approach, the height of the weir from the channel bottom to the crest of the weir should be at least twice as high as the head over the weir. This requirement also implies that collected sediment upstream of the weir should be removed regularly.

- The weir should be kept clean (no algae growth, etc.).

- The weir should be installed in such a manner to ensure that no "leakage" occurs. This requirement should be verified during no-flow conditions.

A Parshall flume is a device consisting of a converging section, a throat and a diverging section. The head of the effluent, at a point in the converging section, is a representative of the flow through the flume. The Parshall flume is usually easier to maintain (clean) than a weir. The upstream flow head is measured at a point which is 2/3 of the length of the converging section (upstream of the throat).

(c) Calibration

Calibration of the flow measurement system is required on a yearly basis.

III. Receiving Water Sampling

(a) Sample Location

(i) Monitoring Program Objectives

The monitoring program objectives must be carefully identified and reviewed before a sampling location is chosen. Determine if the sample site is:

1) a control (receiving water in a location not affected by the discharge);

2) intended to monitor discharge impacts after complete mixing with the receiving water;

3) intended to monitor outside a defined initial dilution zone (see definition below); or,

4) for another specialized purpose.

The initial dilution zone is defined in the British Columbia Pollution Control Objectives as that zone around a waste discharge in a receiving water that is not subject to receiving water objectives. It is physically defined as follows:

1) For point discharges in lakes, estuaries, and marine waters, the zone may extend up to 100 metres horizontally in all directions, but shall not exceed 50% of the width of the water body.

2) For point discharges in rivers and streams, the zone may extend up to 100 metres downstream of the discharge point, but shall not exceed 50% of the width of the river or stream.

3) For multiple point discharges, such as multipoint outfalls, the zone may extend up to 100 metres horizontally from all points of the discharge but shall not exceed 50% of the width of the water body.

The initial dilution zone extends from the point of the discharge in the receiving water to the surface. The zone may not intrude on shellfish beds, restricted routes known to be followed by migrating salmon and trout and other significant biological resources or recreational areas.

The Ministry is currently preparing site specific ambient water quality objectives for high priority water basins throughout the province. These objectives define initial dilution zones for individual water bodies which will replace the application of the more general definition contained in the Pollution Control Objectives.

(ii) General Conditions

The sampling site must be located so as to minimize the impact of influences which are not included in the monitoring program objectives. When sampling rivers and streams, the impact of the following influences should be recognized and addressed:

1) tributary streams entering upstream of the monitoring site;

2) point or non-point sources of contaminants entering upstream of the monitoring site; and,

3) groundwater entering upstream of the monitoring site.

When sampling lakes, the sampling location must take into consideration physical influences such as stratification, mixing and flushing to ensure the objectives of the monitoring program are met. Sampling of marine and estuarine waters must, in addition, take into consideration the specific tidal conditions.

(iii) Rivers and Streams

If sampling outside the initial dilution zone, the sampling site should provide uniform flow and mixing. An initial sampling survey may be required to ensure that uniform vertical and horizontal mixing exists.

Mid-stream sampling is preferable when the monitoring objectives require well-mixed conditions, but sampling from the shore is acceptable if the sampling location is representative of the main flow. Samples should not be taken in backeddies or brackish waters unless required by the monitoring program objectives.

Sampling, where practical, should proceed from downstream to upstream in order to avoid disturbances caused by the sampling itself.

Samples should be taken just below the surface unless the monitoring program objectives require assessment of surface films or samples at depth are required.

(iv) Lakes and Marine Waters

Sites selected and sampling depths will depend on monitoring program objectives. Surface samples should be collected at a depth of 0.5 metres.

(v) Accessibility and Site Identification

The site must be readily and safely accessed at all times of the year when samples are required and the sampling itself must be carried out in a manner which conforms to Workers' Compensation Board Regulations and other applicable safety requirements.

A detailed description of the site must be documented so that a person unfamiliar with the site can use the documentation to find the exact location. For best sampling results, especially for lake and ocean outfalls, the outfall location should be physically marked so that samples may be taken relative to this point of reference.

When data is to be stored on the Ministry of Environment's data storage and retrieval system (SEAM), a SEAM site number will be established by Ministry staff and this number should be used by the Permittee.

(b) Sample Collection Procedures

(i) Grab Sampling

The rationale for grab sampling provided in Section I for effluents also applies to receiving waters.

Surface water grab samples can be obtained by dipping an appropriate sample collection container into the receiving water. The sample should exclude large nonhomogeneous particles such as leaves and detritus. The sampling device or container should face upstream to avoid contamination (by staff conducting the sampling).

When obtaining a surface grab sample from a boat, the sample should be obtained from the upstream portion of the boat to avoid contamination from engine exhaust or leaks. In a quiescent lake or marine situation, the boat should be kept moving slowly forward when taking the sample.

Sub-surface grab samples are obtained using samplers designed to obtain samples from a specific depth. These include Van Dorne bottles, Kemmerer samplers and pumps. Devices constructed of polyvinyl chloride, acrylic plastic and silicone rubber should normally be used, although stainless steel construction can be used, particularly if metals analysis is not required.

(ii) Composite Sampling

The rationale for composite sampling provided in Section I also applies to receiving waters. Receiving water flow variations are not usually significant over the sampling period, therefore, a flow proportional composite is not necessary.

Composite samples of a vertical profile in a lake or slow moving stream can be obtained by using open ended weighted tubing. The top end of the tubing is sealed prior to bringing it into the boat, thereby capturing all the water contained in the tubing. Alternately, a Van Dorne bottle or other similar sampler could be used to collect samples from specific depths which are subsequently combined to form a composite sample.

(iii) Continuous Sampling

Continuous sampling of receiving waters is not normally required but may be required for parameters such as flow, pH, dissolved oxygen or specific conductance under special circumstances. Location of the instrument probe must meet general siting requirements, with emphasis on provision of continuous flow around the probe. The probe must be secured in a manner which will prevent movement or damage during flood events. Instrumentation associated with the probe must be kept within the design temperature range which normally requires housing facilities to eliminate temperature extremes. Calibration should be provided on a regular basis as required.

(c) Other Criteria

Refer to Section I for criteria relating to the following areas:

- Sampling Frequency
- Specifications for Sampler Design and Construction
- Sample Preservation and Storage
- Additional Procedures for Dissolved Nutrients and Metals
- Sample Splitting
- Reuse of Sampling Devices

IV. Groundwater Sampling

(a) Sample Location

The location and depth of monitoring wells should ideally be determined by groundwater hydrology data. The monitoring objectives should be clearly understood so that wells are categorized as either controls or downgradient from suspected sources of contamination. It is essential that one or more control wells be established in any aquifer being sampled. A grid of wells should be established between the potential source of contamination and any downgradient water source of concern, including other aquifers. The purpose of this monitoring is to determine the extent, direction and rate of movement of any plume of pollutants moving through the groundwater and its potential impact on other water sources.

The location of the well should be properly outlined on a cadastral based map showing relative distances from property boundaries. When data is to be stored on the Ministry of Environment's data storage and retrieval system (SEAM), a SEAM site number will be established by Ministry staff and this number should be used by the Permittee. The sampling facility itself must conform to Workers' Compensation Board and other applicable safety requirements and be readily accessible under all expected weather conditions.

(b) Sample Collection Procedures

(i) Well Construction

Sampling wells are to be installed by drilling. The well should be drilled using steel casing where necessary. Upon completion of the hole, a minimum 4 inch diameter PVC plastic casing should be installed and the steel casing removed leaving an adequate extension above ground to prevent entry of surface fluids into the well and to protect the plastic casing from damage. The annular space which is created should be sealed with an appropriate grouting material.

To prevent movement of sand and silt into the well, screens and if necessary, artificial filter packs should be constructed in accordance with the "Guidelines for Maximum Standards in Water Well Construction", Province of British Columbia (June, 1982). Short screen intervals 1 to 2 metres in length to monitor discreet zones are preferred. Grouting procedures described in the same manual should be used to stop groundwater movement between aquifers and to stop the entry of unwanted surface water into the well. In order to prevent contamination, the well casing top should be sealed with an easily removed cap (i.e., a threaded end plug is often used). A locking device is also desirable to prevent vandalism.

Pumping and recovery tests should be conducted to determine aquifer characteristics and to ensure the well is adequately constructed, and is sampling a significant aquifer zone.

(ii) Sample Extraction Techniques

Prior to sampling, a volume of water at least equal to that contained within the casing must be removed to ensure that water is derived directly from the aquifer zone which is being sampled. The degree of purging before sampling will depend on the permeability of geologic materials (bedrock, silty sand, silt, clay, etc.). In higher permeability materials (sand, sand and gravel, etc.) at least 3 well volumes should be removed before sampling. Alternatively, the well may be pumped and the discharge monitored until indicator parameters such as pH and conductivity stabilize.

Sampling devices such as Kemmerer bottles can be used to sample wells, however, experience has shown that they are often inadequate. Disturbance due to introducing and activating the device often stirs up sediment in the well. Because of tight clearance, within the well, the device can easily become jammed in the casing. Stainless steel and teflon bailers of various diameters and lengths can often be used effectively. Pressure-driven, portable sampling systems are available which will collect samples with a minimum of contamination and with a pumping rate sufficient to purge stagnant water from the wells. These are recommended and large groundwater sampling programs should utilize permanently installed, multi-stage, submersible pumps and, if necessary, a portable generator system. Pumps and sampling lines should be constructed of teflon, tygon, polyvinyl plastic, stainless steel or silicone rubber.

Methods used to sample wells should be documented and standardized for each well site. This information may be critical for subsequent analysis and interpretation of analytical results. The Regional Waste Manager may require special sampling techniques if exposure of non-aerated groundwater to the atmosphere is considered to significantly impact sample chemistry.

(c) Other Criteria

Refer to Section I for criteria relating to the following areas:

- Sampling Frequency
- Specifications for Sampler Design and Construction
- Sample Preservation and Storage
- Additional Procedures for Dissolved Nutrients and Metals
- Sample Splitting
- Reuse of Sampling Devices

Appendix 1. Specifications for Sampling Containers and Sample Preservation

Parameter Group [See Section (a)]		Container Type	Container Pre-Treatment [a] [See Section (b)]	Preservation Techniques [b]
1.	Major Ions	polyethylene	none	none
2.	Nutrients	polyethylene	none	refrigerate
2A.	Low Level Nutrients	borosilicate glass (teflon cap)	3	refrigerate
3.	Metals	polyethylene	1	2 ml conc. HNO_3/500 ml or to pH 2
4.	Mercury	polyethylene	2	6 ml 10% $K_2Cr_2O_7$ plus 6 ml conc. H_2SO_4/500 ml or to pH 2
5.	Organics	amber glass (with aluminum foil liner for cap)	5	refrigerate
6.	Oil & Grease	glass (with aluminum foil liner for cap)	4	conc. HCl to pH 2
7.	Phenols	glass (with aluminum foil liner for cap)	4	a) refrigerate; b) 10% H_3PO_4 to pH 4 plus 5 ml 20% $CuSO_4$/1000 ml
8.	Sulphides	polyethylene	none	1 ml 2N ZnOAc/500 ml; (exclude air)
9.	Cyanides	polyethylene	none	10 N NaOH to pH 12

Appendix 1 (Cont'd)

Parameter Group [See Section (a)]	Container Type	Container Pre-Treatment [a] [See Section (b)]	Preservation Technique [b]
10. Total/Inorganic Carbon	polyethylene	none	refrigerate; (exclude air)
11. Chemical Oxygen Demand (COD)	polyethylene	none	0.2 ml conc. H_2SO_4/250 ml
12. Biochemical Oxygen Demand (BOD)	polyethylene	none	refrigerate; (exclude air)
13. Residues (solids)	polyethylene	none	refrigerate
14. Alkalinity	polyethylene	none	refrigerate
15. pH	polyethylene	none	refrigerate
16. Indicator Tests	polyethylene	none	refrigerate
17. Coliforms	glass, polypropylene, polyethylene (auto clavable)	6	a) refrigerate; b) 0.1 ml 10% NaS_2O_3/125 ml; (for chlorinated samples only)

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[a] Containers which undergo no pre-treatment should be rinsed with distilled water (or sample) prior to use.

[b] All chemical preservatives used in sample preservation are to be reagent grade or better.

Appendix 1 (Cont'd)

Section (a)

1. Major Ions

   calcium
   chloride
   conductivity
   fluoride
   hardness
   magnesium
   potassium
   salinity
   sodium
   sulfate

2. Nutrients

   ammonia
   nitrate
   nitrite
   O-phosphate
   phosphorus
   total kjeldahl nitrogen

3. Metals

   aluminum
   antimony
   arsenic
   barium
   boron
   cadmium
   chromium
   cobalt
   copper
   iron
   lead
   manganese
   molybdenum
   nickel
   selenium
   silver
   titanium
   vanadium
   zinc

4. Mercury

Appendix 1 (Cont'd)

Section (a) Cont'd

5. Organics

    2 - (thiocyanomethylthio) benzothiazole (TCMTB)
    Copper-8-quinolinolate
    chlorinated hydrocarbons
    hydrocarbons
    pentachlorophenols (PCP)
    petroleum distillates
    polychlorinated bypenyls (PCB)
    resin acids
    tri and tetra chlorophenols
    various toxic organics

6. Oil & Grease
7. Phenols
8. Sulfides
9. Cyanide

    strong acid dissociable
    weak acid dissociable

10. Total/Inorganic Carbon
11. Chemical Oxygen Demand
12. Biochemical Oxygen Demand
13. Residues (solids)

    filterable residue
    non-filterable residue
    total residue
    volatile non-filterable residue
    volatile total residue

14. Alkalinity
15. pH
16. Indicator Tests

    color
    turbidity

17. Coliforms

    fecal
    total

Appendix 1 (Cont'd)

Section (b)

Parameter Group	Cleaning Procedure
1. Metals	1. rinse in 25% HNO_3 2. rinse with deionized water 3. air dry or oven dry at 50°C
2. Mercury	1. rinse in chromic acid (add 380 g $K_2Cr_2O_7$ to 55 L 4.5% H_2SO_4) 2. rinse with deionized water 3. air dry or oven dry at 50°C
3. Low Level Nutrients	1. soak in HCl for 15 minutes 2. rinse with deionized water 3. soak in biodegradable liquid soap for two hours 4. rinse with hot water 5. rinse with deionized water 6. air dry
4. Oil & Grease and Phenols	1. soak in concentrated powder soap solution for at least 8 hours 2. rinse with hot water 3. rinse with deionized water 4. rinse with hexane 5. air dry
5. Organics	1. soak in concentrated powder soap solution for at least 8 hours 2. rinse with hot water 3. rinse with deionized water 4. rinse with acetone 5. heat treat at 350°C for at least 8 hours
6. Coliforms	1. autoclave at 120°C and 15 psig for 20 minutes